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AGRICULTURAL MEMORANDUM No 1051

AN ASSESSMENT OF THREE THERMOMETER SCREENS

S N WASS

Summary

Three experimental thermometer screens are compared with a standard large screen. Two are considered suitable for agrometeorological work. They both tend to overestimate the maximum temperature by about 0.4°C and underestimate the minimum by about 0.1°C but there is excellent agreement between wet bulb depressions.

Introduction

There is a need in agrometeorological studies for small, low cost, light-weight thermometer screens. Such screens must be capable of giving consistent results when compared with standard instruments and perhaps be suitable for in-crop measurements. This memorandum presents the results of comparisons of 3 such screens with a standard large thermometer screen. A second large screen was included in the trial in order to measure the variability between similar screens.

All 3 experimental screens were 'sandwich' type derivatives; their details are given in Appendix 1 and figures 1-3 but brief descriptions are as follows:-

TABLE 1

SCREEN No	DESIGNER	REFERENCE	CONSTRUCTION
4	Barrowcliffe	1	Stack of 6 plastic saucers
5	Bellaire and Anderson	2	3 PVC plates separated by 3 semi circular vanes
3	Wass	5	5 flat dural plates

All 5 screens were mounted such that the thermometers were in a 3 m square (fig 4), 1.25 m above short grass outside the Bristol Regional Office. The original intention was only to compare dry bulb temperatures but because initial results showed 2 of the screens to be performing better than expected

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the trial was extended to investigate wet bulb depression measurements. The Bellaire version was considered unsatisfactory and was dropped from the experiment.

The Assessment

Temperatures were measured with 125 mm and 50 mm thermistors and recorded on 1 or 2 synchronised 'Squirrel' data loggers at 15 minute intervals. Resolution of the temperature measurements was 0.1, 0.16 or 0.2°C, depending on the loggers configuration. Because the equipment was sometimes required for other investigations measurements were taken on an opportunity basis between June 1984 and November 1984.

Throughout the testing the thermistors were occasionally compared over a 24 hour period by housing them all in the same standard sscreen: correcions were less than 0.1°C.

Results

Comparisons of maximum, minimum and mean daily temperatures are shown in Table II. Maximum temperatures were taken as the highest of a day's 15 minute observations, minima as the lowest and the means as the average of the 96 readings taken during the day.

TABLE II

DIFFERENCES BETWEEN DRY BULB IN EXPERIMENTAL SCREENS AND LARGE SCREEN

SCREEN	MAXIMUM		MINIMUM		MEAN		N/d.o.f
	MEAN	SD	MEAN	SD	MEAN	SD	
CONTROL (LARGE SCREEN)	0.09	0.10	0.11	0.12	0.09	0.09	30/28
BARROWCLIFFE (SAUCER)	0.43	0.25	-0.18	0.21	0.03	0.10	37/35
BELLAIRE (VANE)	0.89	0.57	-0.35	0.36	0.18	0.07	7/6
WASS (SANDWICH)	0.36	0.21	-0.06	0.16	0.12	0.12	27/25

Because of the relatively large and statistically significant differences observed with the Bellaire screen further measurements were not made and effort (and equipment) turned to measuring wet bulb depressions. Matched pairs of thermistors were fixed in each screen with a sack type wick attached to one of each pair. From the 15 minute observations wet bulb depressions were calculated and the differences between those measured in each screen are shown in Table III.

TABLE III

DIFFERENCES BETWEEN WET BULB DEPRESSION IN EXPERIMENTAL AND STANDARD SCREENS (°C)

	MEAN DIFFERENCE	STANDARD DEVIATION	NO OF OBSERVATIONS
STANDARD	0.03	0.14	2021
BARROWCLIFFE SAUCER	0.02	0.12	1710
WASS SANDWICH	0.10	0.18	1710

DISCUSSION

DRY BULB

Barrowcliffe (1984) screen is made from thin plastic saucers and is designed to house small thermistors for in-crop measurements. The screen built by Wass (1983) is made from 18 SWG dural and is designed to shield mercury in glass thermometers. Both screens respond in a similar manner: they overestimate the maximum and underestimate the minimum temperatures. Standard deviations of differences in temperature are of the same order as the resolution of the measurements (0.12, 0.18). It is of interest to note that Smith (1951) reported the standard deviations of the differences between 4 standard screens on the same site at Kew to be 0.18°C.

Tests on the earlier version of the Wass screen showed the error in the maximum to be correlated with the value of that maximum; ie, the hotter the day the bigger the error. With the addition of an extra (lower) plate to that screen this is no longer the case. Although a systematic error (0.36°C) remains it is smaller, less variable and independent of the maximum temperature - at least in the range of these tests (15°-29°C).

The Bellaire screen also responded in a similar way (over/under estimation of maximum/minimum) but the differences (0.9,-0.3) were considered unacceptably large. This is in contrast to Sparks' (1972) report and its poor performance may be attributable to slight design changes and construction material.

The characteristic response of all 3 screens is almost certainly due to their lower thermal mass and shorter response time than a large wooden screen.

WET BULB DEPRESSION

Comparison of wet bulb depressions showed a remarkable degree of agreement with the Saucer performing as well as the standard screen. The small systematic error of 0.10°C in the Sandwich screen is attributable to its open construction allowing higher ventilation rates.

CONCLUSIONS

Both the Saucer and the Sandwich screen are considered suitable for use in Agrometeorological (and similar) work. If used for purposes when only mean temperatures are required (degree days, T-sums etc) then no corrections need be applied. If readings are being compared with standard screened maximum or minimum thermometers then corrections derived from Table I should be applied. The small standard deviations imply that they are sufficiently self consistent to be used for intercomparison purposes (eg frost surveys, micro climatic studies).

The excellent agreement in the wet bulb depression measurements also make either screen suitable for humidity measurements.

References

Barrowcliffe, R. 1984. An improved 'saucer' screen for wet and dry thermistors. Agricultural Memorandum No. 1015.

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Wass, S.N. 1983. Accuracy of temperatures measured in a sandwich screen. Agricultural Memorandum No. 1005.

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Key words:- SCREEN, TEMPERATURE, WET BULB, SANDWICH.

APPENDIX I

SCREEN DESCRIPTIONS

1. BARROWCLIFFE SAUCER

This screen, described in more detail by Barrowcliffe 1984, consists of 6 white plastic flower pot saucers. They are held in a stack by brass rods and separated by 30 mm lengths of plastic tubing. Thermistors are mounted vertically and suspended on a 'gallows' arrangement. The wet bulb reservoir is fastened under the lowest saucer and replenised by using a funnel fixed in the next higher plate. See figure 1.

2. BELLAIRE AND ANDERSON VANE

Thermistors are shielded by 3 semi-circular vanes mounted asymetrically between 2 plates with a third lower plate acting as a radiation shield and support for the wet bulb reservoir. The vanes were made from 4 mm grey PVC and the 3 plates from 6 mm PVC with the top one perforated to encourage convection. This structure is capped with a 320 mm square, 16 SWG white, dural sheet spaced 20 mm above the top PVC plate. See figure 2.

3. WASS SANDWICH

The screen (see figure 3) is similar to that described in Agricultural Memorandum 1005 (Wass 1983) but has had an additional plate added underneath in an attempt to reduced the errors found in previous tests.

It consists of 5 horizontal, rectangular, 18 gauge alloy sheets separated by low conductivity spacers and hinged laterally for access. External surfaces are painted gloss white and internal surfaces matt black. The second lowest plate is strengthened and rivetted to a box section tube which is screwed to a 50 mm square post 1.2 m AGL. Thermistors are mounted horizontally along the major axis (though there is provision for mercury in glass thermometers) and a Meteorological Office pattern wet bulb reservoir is held between the two lowest plates.

Figure 1 BARROWCLIFFE SAUCER

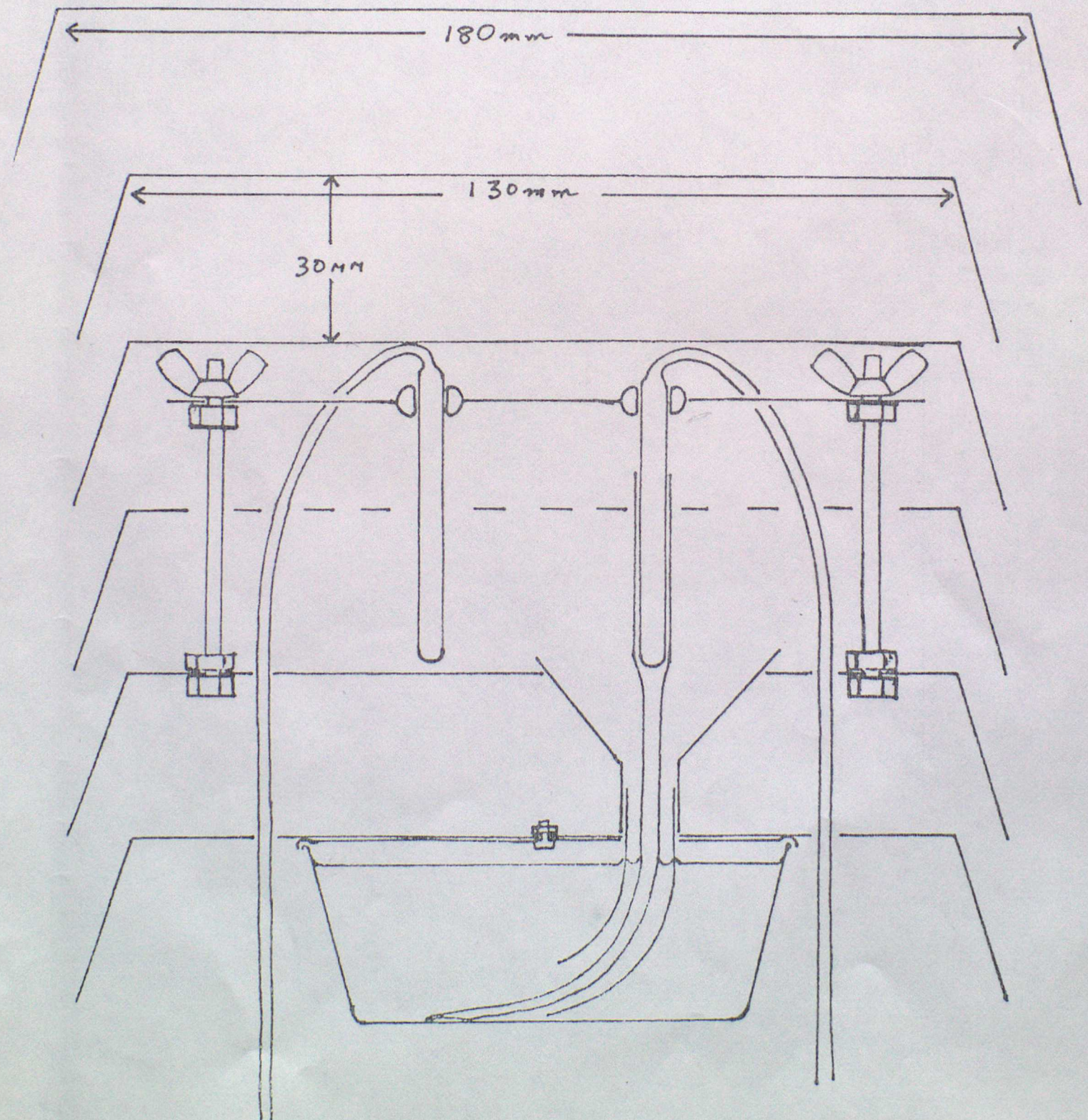
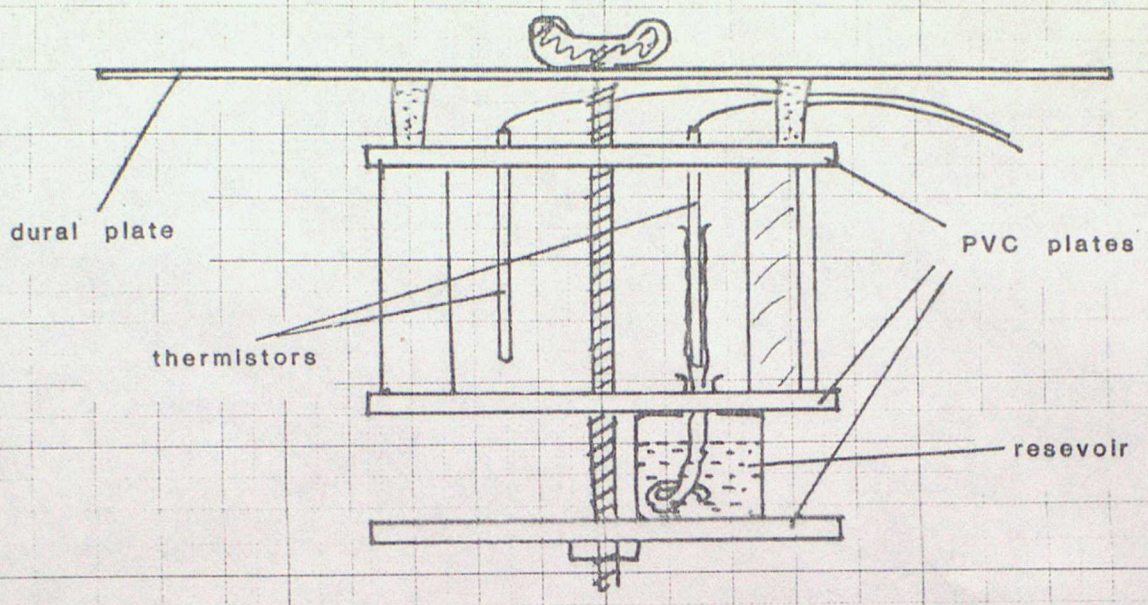
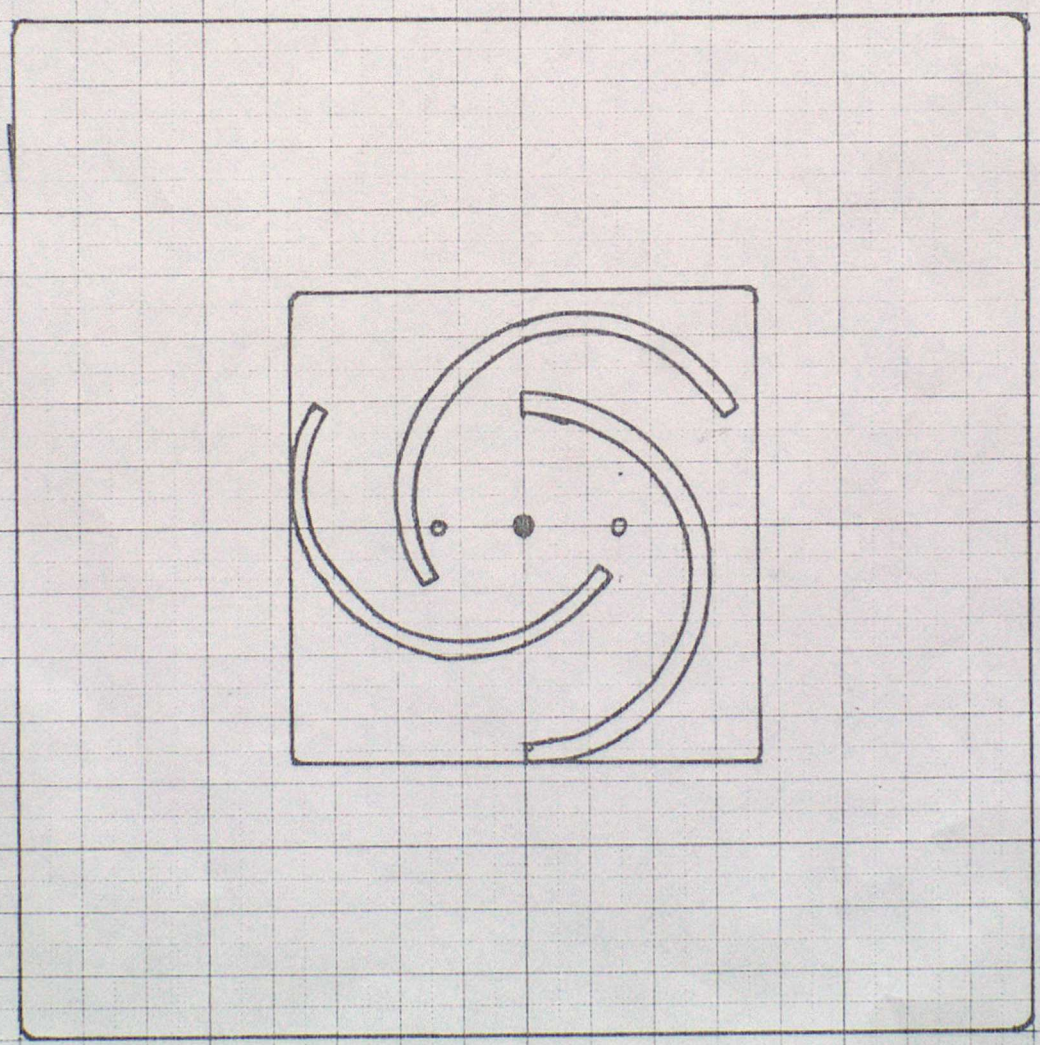


Figure 2 BELLAIRE AND ANDERSON





Scale 2cm

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Figure 3

WASS SANDWICH SCREEN

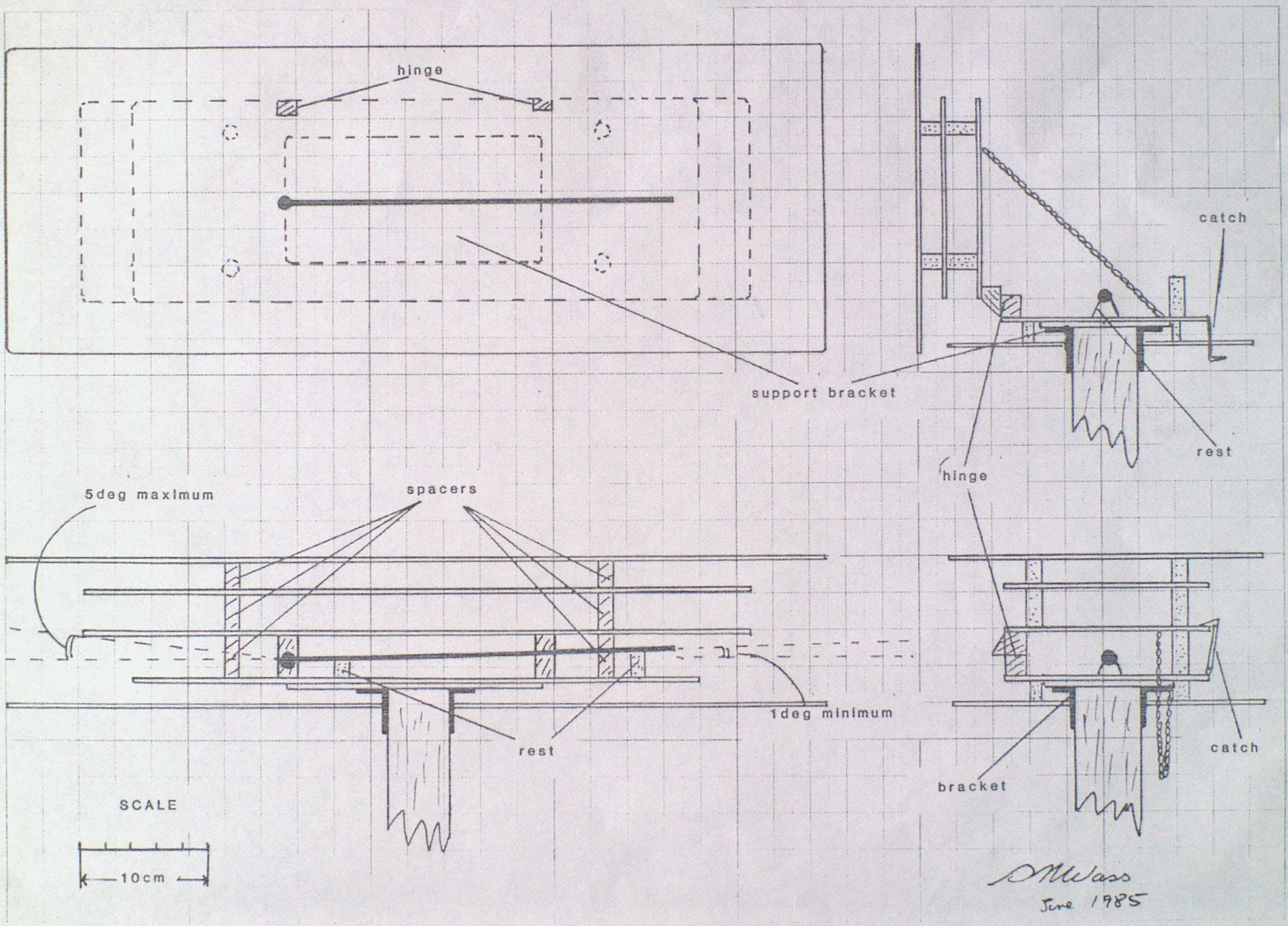
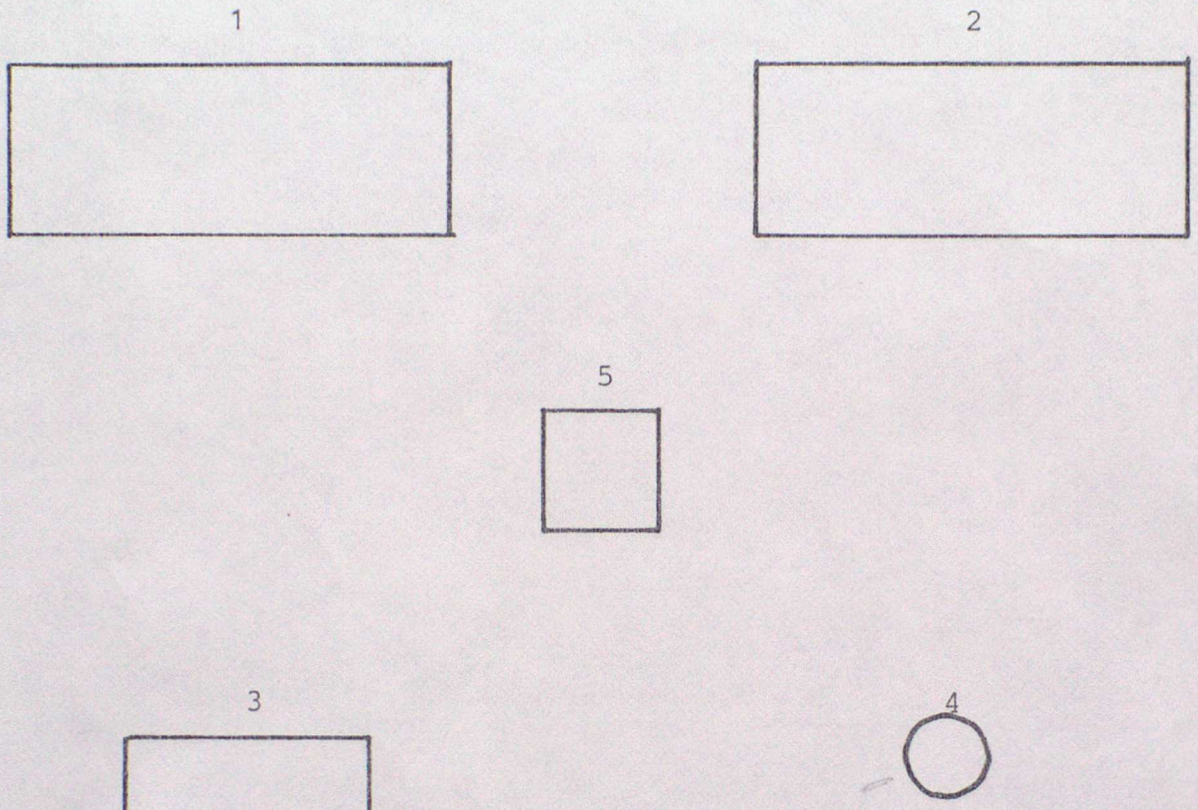


Figure 4 EXPERIMENTAL LAYOUT



SCREENS

1. COMPARISON STANDARD
2. CONTROL STANDARD
3. WASS SANDWICH
4. BARROWCLIFFE SAUCER
5. BELLAIRE AND ANDERSON